

4. (amended) A method of manufacturing a semiconductor apparatus comprising the steps of:

laminating upwards a polycrystal silicon film or an amorphous silicon film, a tungsten nitride film or a titanium nitride film, and a tungsten film on a silicon substrate; and

performing a dry-etching of said tungsten nitride film or said titanium nitride film and said tungsten film with only a single mixed gas containing fluorine-containing gas that includes a compound having fluorine and carbon in a molecule, chlorine or hydrogen bromide, oxygen and nitrogen so that a gate electrode is formed.

REMARKS

This is a full and timely response to the final Official Action mailed June 21, 2001. Reexamination and reconsideration in light of the above amendments and the following remarks are courteously requested.

By the foregoing amendment, claims 1 and 4 have been amended. No claims are added or canceled. Thus, claims 1 to 8 are currently pending for the Examiner's consideration. Although after a final Office Action, entry of the amendment is respectfully requested. The amendment is believed to be compliant with 37 C.F.R. § 1.116 in light of the Examiner's thorough understanding of the teachings of the present application, and therefore the likelihood of the Examiner's

anticipation of an amendment of such a scope as the present amendment entails. No claims are added, and the amendment should clearly place the claims in condition for allowance. Thus, entry of the amendment is requested.

The Examiner rejected claims 1 to 8 under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,146,542 issued to Ha et al. ("Ha") in view of U.S. Patent No. 5,164,330 issued to DAVIS et al. ("Davis"). These rejections are respectfully traversed.

It is the Examiner's position that the Ha patent teaches substantially all of the claimed limitations, with the major exception being that Ha fails to specifically teach that a dry etching mixed gas includes a fluorocarbon. Applicant generally agrees with the Examiner's assertions regarding this deficient teaching from the Ha patent, for the following reasons.

The present application mentions in the background section the disadvantages of using non-carbon compounds that include fluorine as an etching agent for tungsten. The disadvantages include microloading and an impractical etching rate.

In contrast, the Ha patent teaches in its background section that etching of tungsten is performed using fluorine compounds that do not contain carbon, including a mixture of SF₆ and NF₃. The passage of Ha cited by the Examiner simply reads that a fluorine compound is used to etch tungsten

layers, but it would be inferred by a person of skill in the art that the same compounds cited in the background section for this process would be used according to the Ha invention.

This point is further established by the fact that Ha goes on to disclose that a carbon-containing fluorine compound could be used in a subsequent etching step to remove not the tungsten layers, but the diffusion barrier layer (column 4, lines 5 to 8). Therefore a person of ordinary skill in the art would read Ha and ascertain that Ha suggests that no change in etching gas from those disclosed in the background section would be used for etching tungsten layers, but that a carbon-fluorine type etching gas could be used in subsequent etching steps.

Because Ha fails to teach or suggest the use of carbon-containing fluorine compounds for etching tungsten layers, the Examiner applies the Davis patent for its teachings that fluorocarbon compounds may be used to etch tungsten and an underlayer that can include titanium nitride, and asserts that it would be obvious to substitute the fluorocarbon compound of Davis for the inorganic fluoride compounds of Ha. To this point, Applicant disagrees with the Examiner.

Davis teaches away from using fluorocarbon compounds as primary etching gases due to their tendency to cause carbon contamination that builds up on reactor walls and on an electrode in an etching chamber (col. 2, lines 36 to 43).

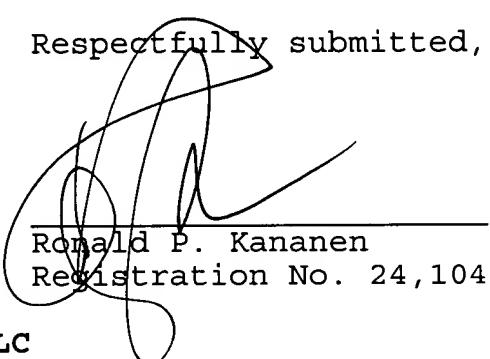
Thus, Davis teaches that inorganic fluoride compounds such as NF₃/Ar mixtures should be primarily used "to remove the bulk of a tungsten film" followed by smaller etch steps that may include fluorocarbon compounds (col. 8, lines 22 to 29). In contrast, the present invention involves using the fluorocarbon compound in a gas mixture of oxygen, nitrogen, and a chlorine or hydrogen bromide compound to remove an entire layer of tungsten and an underlayer of tungsten nitride or titanium nitride.

A reference must be considered for all it teaches, including disclosures that teach away from the invention as well as disclosures that point toward the invention. Ashland Oil, Inc. v. Delta Resins & Refractories, Inc. 776 F.2d 281, 227 U.S.P.Q. 657 (Fed. Cir. 1985). As Davis teaches away from the use of fluorocarbon compounds as primary etching gases of tungsten due to their tendency to cause carbon contamination that builds up on reactor walls and on an electrode in an etching chamber, it is clear that a person of ordinary skill in the art would not arrive at the presently claimed subject matter from reviewing the teachings of Ha and Davis together. Consequently, the claims are not obvious, and the rejections of claims 1 to 8 should be withdrawn.

For the foregoing reasons, all the claims now pending in the present application are believed to be clearly patentable over the prior art of record. Accordingly, favorable

reconsideration of the claims in light of the above remarks is courteously solicited. If the Examiner has any comments or suggestions that could place this application in even better form, the Examiner is requested to telephone the undersigned attorney at the below-listed number.

Respectfully submitted,


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Appendix

Amendments to the Claims

1. (amended) A dry etching method comprising the step of: dry-etching tungsten using only a single mixed gas including a fluorine-containing gas that includes a compound having fluorine and carbon in a molecule, chlorine or hydrogen bromide, oxygen, and nitrogen.

4. (amended) A method of manufacturing a semiconductor apparatus comprising the steps of:

laminating upwards a polycrystal silicon film or an amorphous silicon film, a tungsten nitride film or a titanium nitride film, and a tungsten film on a silicon substrate; and performing a dry-etching of said tungsten nitride film or said titanium nitride film and said tungsten film with only a single mixed gas containing fluorine-containing gas that includes a compound having fluorine and carbon in a molecule, chlorine or hydrogen bromide, oxygen and nitrogen so that a gate electrode is formed.

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